EXHIBIT DX78

TO DECLARATION OF PETER J GOSS IN SUPPORT OF REPLY TO DEFENDANTS' MOTION TO EXCLUDE OPINIONS AND TESTIMONY OF PLAINTIFFS' PLAINTIFFS' ENGINEERING EXPERTS

Deposition of Expert Said Elghobashi, Ph.D.
Mechanical and Aerospace Engineering

Page Line	Correction	Reason
50, 18	See Exhibit A	To Correct and Clarify
56, 20	See Exhibit A	To Correct and Clarify
57, 24	See Exhibit A	To Correct and Clarify
70, 6	See Exhibit A	To Correct and Clarify
79, 24	See Exhibit A	To Correct and Clarify
105, 9	See Exhibit A	To Correct and Clarify
106, 25	See Exhibit A	To Correct and Clarify
107, 6	See Exhibit A	To Correct and Clarify
107, 7	See Exhibit A	To Correct and Clarify
111, 22	See Exhibit A	To Correct and Clarify
113, 2-116, 7	Witness incorporates the materials in Exhibit B	Clarification of the thinking and analysis I performed that permitted me to calculate a reliable and accurate approximation of the temperature and velocity. This analysis involved a methodology that I could not explain verbally in a deposition. The explanation required mathematic formulas and illustrations which are contained in Exhibit B.
135, 8	See Exhibit A	To Correct and Clarify
139, 24	See Exhibit A	To Correct and Clarify
142, 9	See Exhibit A	To Correct and Clarify
148, 5	See Exhibit A	To Correct and Clarify
149, 4	See Exhibit A	To Correct and Clarify
149, 23	See Exhibit A	To Correct and Clarify
164, 11	See Exhibit A	To Correct and Clarify
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190, 6	See Exhibit A	To Correct and Clarify
196, 23	See Exhibit A	To Correct and Clarify
198, 17	See Exhibit A	To Correct and Clarify
201, 6	See Exhibit A	To Correct and Clarify

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201, 24	See Exhibit A	To Correct and Clarify
202, 13	See Exhibit A	To Correct and Clarify
203, 3	See Exhibit A	To Correct and Clarify
203, 19	See Exhibit A	To Correct and Clarify
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248, 4	See Exhibit A	To Correct and Clarify
253, 6	See Exhibit A	To Correct and Clarify
253, 9	See Exhibit A	To Correct and Clarify
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266, 12	See Exhibit A	To Correct and Clarify
267, 11	See Exhibit A	To Correct and Clarify
272, 16	See Exhibit A	To Correct and Clarify
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289, 21	See Exhibit A	To Correct and Clarify
290, 2	See Exhibit A	To Correct and Clarify
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THE WITNESS: No. No, they were not. Yeah.

BY MR. GORDON:

Q. Okay. Just -- just to save counsel some time and effort, every question I ask you, I only want what you know. So if you don't know something, then you can say, "I don't know."

A. Okay.

Q. But if you do know, then you can answer.

A. Sure.

Q. This way, your counsel won't have to --

A. Okay. Okay.

Q. -- you know, say "if you know" --

A. Okay.

Q. -- anymore. Okay?

The picture on the Exhibit 12, page 10, I guess Figure 4(b), where did that picture come from?

A. I don't recall. It could have been being Gabriel, the counsel Gabriel.

MS. ANDREWS: If you don't recall, you don't recall.

THE WITNESS: I don't -- okay. I don't recall.

MS. ANDREWS: See, Counsel also doesn't want me to tell you this, but I really am going

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model --
A. Correct.
Q. -- correct?
Based on boundary conditions that you provided to him, right?
A. Correct.
Q. Okay. Did Dr. Apte participate in actually dev- -- developing the -- the boundary conditions?
A. No. I did.
Q. Okay. Was he physically present, you know, in Santa Monica when you went into that operating room?
A. No.
Q. Was he physically present for any aspect of this, or was this just something where he, up in Oregon, ran the -- ran the code?
A. So we met few times.
Q. Where?
ing
A. At APS meet- -- American Physical Society meeting in Portland.
Q. Okay. When -- do you know when that was?
A. This was in November, before Thanksgiving.

Q. Now, did he charge for his work?

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A. Correct.
Q. Did he bill the plaintiffs separately for that?
A. No. He -- only with me.
Q. Okay. And did -- did you then bill the plaintiffs' counsel for Dr. Apte's work?
A. Correct.
Q. Okay. Let's -- we -- we're jumping around a little bit because I'm just trying to put things together.
A. Yeah.
Q. 9C is the -- is the third invoice that was provided this morning. What -- and that -- I -- what -- what's the period of time that that covers?
A. February 17 to March 17.
Q. 2017, right?
A. Correct.
Q. Okay. So in those three invoices, 9A, 9B and 9C, I don't see any reference to a payment for Dr. Apte or any -- any other outside consultant. Did I -- did I miss it or would -- would there have been some other invoice?
A. Right. I -- I paid Dr. Apte. I paid him after I ~~get~~ got the funds from the counsel.
Q. Okay. But in order to get the funds from

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photographs -- what was that exhibit?
MS. ANDREWS: Eight.
THE WITNESS: Eight.
BY MR. GORDON:
Q. Exhibit 8. Those were taken at UC Irvine?
A. ~~Nine~~ -- no. Nein
Q. Oh, I'm sorry. Where were those photos taken?
A. Santa Monica.
Q. Oh, I'm sorry. Okay. So those photographs --
A. From Santa Monica.
Q. I see. Okay. How -- how was it that you gained access to an operating room at -- in Santa Monica? Is that something you arranged?
A. No.
Q. Do you know who arranged it?
A. The counsel.
Q. Okay. And do -- what -- was it -- what type of operating room was it that you were given access to?
A. Orthopedic surgery operating room.
Q. Okay. And what time of day was it?
A. We arrived at 9:00 o'clock and we stayed until late.

EXHIBIT A

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Bair Hugger blanket and nothing else; is that --

MS. ANDREWS: Objection. Argumentative. Calls for speculation.

BY MR. GORDON:

Q. Was that your understanding?

A. We asked the RN to set up the patient exactly as in operation.

Q. Okay. And so your understanding was that in a regular operation, a single plastic drape is placed over the Bair Hugger?

MS. ANDREWS: Objection. Mischaracterizes prior testimony. Calls for speculation. It's been asked and answered.

THE WITNESS: I cannot answer the question.

BY MR. GORDON:

Q. You -- you don't have an -- an understanding as to what your understanding was as to whether that was representative of a typical operation or not?

MS. ANDREWS: Objection. Argumentative. Misleading.

THE WITNESS: I was told the setup was a normal ~~operation~~ -- operating room setup.

BY MR. GORDON:

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MS. ANDREWS: Please.
THE WITNESS: Please.
(Record read as follows:
"Q. Are you aware of hot wire anemometers that are available that measure both mass flow rate and temperature?")
THE WITNESS: The hot wire anemometers measures velocity, not mass flow rate.
BY MR. GORDON:
Q. Okay. Is there a way to calculate mass flow rate if you know the velocity and the area?
A. Yes.
Q. Okay. And the area, you actually took measurements, that -- that allowed you to actually measure the area of the drape edge, correct?
A. Correct.
Q. And you incorporated those measurements in your CFD, correct?
A. Correct.
Q. But you have no actual measurements of the velocity of the air exit -- exiting the edge of the blanket, correct?
MS. ANDREWS: Objection. Asked and answered. Argumentative. Mischaracterizes prior

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testimony.
THE WITNESS: If you know the mass flow rate from the blower and you know the drape geometry, you can get the velocity leaving.
BY MR. GORDON:
Q. So you took the mass flow rate as it exits the Bair Hugger where? At the -- at the nozzle end or out the blanket?
MS. ANDREWS: Well, that's compound, Counsel. Objection.
THE WITNESS: The mass flow rate is the same.
BY MR. GORDON:
Q. Okay. And how long does it stay that way?
MS. ANDREWS: Objection. Calls for speculation.
THE WITNESS: Always.
MS. ANDREWS: Improper hypothetical. Sorry.
BY MR. GORDON:
Q. So once the air exists the Bair Hugger at whatever its mass flow rate, it maintains that mass flow rate forever. Is that your testimony?
A. The mass flow rate leaving the blower is the same mass flow rate that leave s the blanket

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holes, forever.
Q. Okay. Once it leaves the blanket holes, you're saying it maintains that same mass flow rate forever?
A. The mass flow rate leaving the blanket exit -- that leaves the blower exit is identical to the mass flow rate that leaves the blanket holes, period.
Q. Okay. I -- and I'm taking it to the next step. The mass flow rate of the air leaving the blanket holes, does that stay constant forever?
MS. ANDREWS: Objection. Asked and answered.
THE WITNESS: As long as the blower running, the mass flow rate will be the same.
BY MR. GORDON:
Q. So I -- I want to -- I want to make sure I understand, because you're -- you're -- this is your area of expertise, not mine. If we were to set up the Bair Hugger blanket at the -- that far end of the room such that the -- the jets were pointing towards the -- the other end of the room, you're saying that the mass flow rate right outside the blanket would be identical to the -- the far wall?
A. I did not say that.

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relationship between the amount of the air moving over a particular area over a period of -- particular period of time, right?

A. The mass flow rate that comes from the blower would remain fixed until it leaves the drape edge.

Q. Will the velocity remain fixed?

A. Never.

Q. Okay. Will the temperature remain fixed?

A. If the drape is insulated, it would remain without a change.

Q. For how long?

A. The longer, the better.

Q. So a insulated drape that was 100 feet long, if you put the Bair Hugger blanket up against the top of it at the 100 feet below, the -- the temperature would remain exactly the same; is that what you're saying?

A. No.

Q. Would it be more, less, or what would happen to it?

of the s

A. It depends on the conditions surrounding.

Q. And what -- what are the conditions that will impact it?

A. The ambient flow, ambient temperature.

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A. This is the laminar flow. I would say for a laminar flow, it will be fine for that student to do it, yes.
Q. Without any further validation?
A. We always validate codes always. This is undergraduate student wrote his code under my supervision, so I told him to do that. If my own code, which I have been developing for 30 years, then I know exactly -- it's already validated for canonical flows and other things, then I know what is like. When you test an airplane, you test it for many years, then you give it to the pilot to take passengers. Codes are like that.
Q. Well, in fact, if you've got an airplane design that's been successful for many years and you change some small aspect of the design, there's always some validation that that design change is not going to impact its --
A. I'm aware.
Q. -- functionality, correct?
[Reporter requests clarification.]
MR. GORDON: Functionality.
THE WITNESS: I'm aware of.
BY MR. GORDON:
Q. So the fact that an airplane flies under

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validation with experimental observations."
A. Correct.
Q. Why did you mention anything about the Saarinen paper?
A. It's here. It's written.
Q. No, I understand, but, I mean, you -- what -- what difference does it make that -- what the Sarimen -- Saarinen study did or didn't show?
A. I described here what Saarinen did. What -- what -- what do you want?
Q. Right, but you say it -- it showed that LES can accurately predict such flows through validation with experimental observations.
A. Okay.
Q. Your testimony is that LES is validated, and so you -- you don't -- it doesn't need any validation in --
A. Sir --
Q. -- other contexts, right?
A. Sir, let me explain to you. Code takes 15 to 20 years to develop. It's your code. You know everything about it. I cannot take a code from here (indicating) to say the -- what's quality. We just are referring that there ~~are~~ is only one paper in the market for LES. That's all. I'm not saying --

paper.
Q. Okay. Well, let's take a look at Exhibit 17, the Saarinen paper. First of all, you -- in -- in your description of it, you say it -- it was applied to operating rooms, right?
A. Yeah, it is. They said that, I think.
Q. Okay. Could you show me where they say it, that their study involved an operating room?
A. It says that hospital isolation room, single hinged doorway. It's in the title.
Q. Is -- is it your understanding that an isolation room is the same thing as an operating room?
A. As far as geometry. I don't know the use of it, but geometry, yes. Like how many meters, how many meters, that's all.
Q. Well, that would be true of a conference room that was the same --
A. No.
Q. -- size, right?
A. A conference room is not a hospital room.
MS. ANDREWS: Wait, wait.
BY MR. GORDON:
Q. Well, tell me what's -- that's what I'm trying to understand. What's different about the

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your --
A. It was just telling the readers of my report --
[Reporter requests clarification.]
THE WITNESS: We are ~~Were~~ just telling the people reading my report there is only one study mentioning LES. That's it. If I want to use this for research, I would do more work to find it junk or not junk. I don't trust anything.
BY MR. GORDON:
Q. So if you were doing the Bair Hugger thing for research --
A. Yes.
Q. -- you would have wanted to do more in terms -- in terms of measurements, validation --
A. No.
Q. -- right?
A. No. The code has been tested for 15 years for more complex flows, then it will do the Bair Hugger immediately. It's a lower level. Bair Hugger is a lower level than what the code was tested for. Trust me.
Q. So what -- what -- if you -- when you said about Saarinen, if you were doing this for research, you would do more. I'm trying to understand --

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A. Okay.
Q. -- what you're saying.
A. If you want me to refer this and you want me to ask about the quality ~~or~~ of some smoke experiments, then I have to dig harder and probably contact those authors to ask about what code they used, but I didn't. This is only for introduction.
Q. So in your experience, once a code has been validated, from that point on, it's 100 percent accurate in predicting everything as long as you put in boundary conditions that replicate some aspect of reality?
MS. ANDREWS: Objection. Asked and answered.
THE WITNESS: If it is my code or code that I used, then I will do that. Then I know where it was tested. If you have 15 years, I see all the paper that tested that code, then I go ahead. I trust it. Especially -- especially if the tests had all the physical ingredients that the next problem will have. Okay? If the physical ingredients are not the same, then I have to do new validation. That is what we do all our life. You don't trust a code because it's your code or anything. If it's a new physics, then you test it again. But if the

THE WITNESS: S-N-Y-D-E-R, Snyder.
BY MR. GORDON:
Q. That's a paper about retail food operations?
A. Correct.
Q. Okay. And what was it you got from this --
A. He men- --
Q. -- Snyder paper?
A. He mentioned the number 4 billion squames and ~~has~~ as he detailed -- the title looks funny, but it's a scientific paper.
Q. Okay. Well, the -- I'm trying -- trying to understand.
A. So I'm --
Q. Okay. Go ahead.
A. Okay. So 2 meters square by a little thing, 25-micron by 25-micron, you get 4 billion. And the paper by Noble said the human being sheds 4 billion squames in one to four days. So I took one, which is the very conserve -- I took four days, means 1 billion a day. That's a very conservative estimate.
[Reporter requests clarification.]
THE WITNESS: Estimate.

A. Okay. Here we go. So first I put the squames all on the floor because in a real room, they are not on the floor. It would have been very easy to put them outside -- above the -- but then I made it so conservative -- I gave 3M the best scenario, from ~~number~~ 2 percent of the squames of four human beings and all on the floor. I could have put them in the -- spread in the room, then we follow how they spread.
[Reporter requests clarification.]
THE WITNESS: How they spread, S-P-R-E-A-D.
BY MR. GORDON:
Q. Did you read any studies or any literature that suggested that 3 million squames in the area you defined, one centimeter above the floor, is representative of what actually happens in an actual operating room during a surgery?
A. I didn't read a paper that ~~have~~ has 3 million. I made an estimate of conserv- -- I could have put 10 million or 20 million, which is still a small percentage of the people. I just took the lowest one.
Q. But you -- your number, whatever it is, assumed, based on your calculations, that the squames that people were -- were shedding were

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settling to the floor and staying there?

A. Again, I put them on the floor first and let the fluid mechanics of the room disperse them. I could -- if I had put them spread already, then I will be biasing the result that Squames could ~~be~~ go to the knee directly, if they are above the lamp or something. So I made it so that their position would not ~~be~~ OK a cause of the result. So I made it so that it would not be causing artificial results. I put them far away from everybody on the floor.

Q. Do you have, other than your own calculations, any support for the idea that 3 million squames on the floor in the area you've prescribed is realistic --

MS. ANDREWS: Objection.

BY MR. GORDON:

Q. -- based on actual surgeries?

MS. ANDREWS: Objection. Argumentative. Form.

[Reporter requests clarification.]

MS. ANDREWS: Form.

THE WITNESS: When papers say a human being sheds 4 billion squames in one day to four days, I took one day. I did not take one day. I took 2 percent of that one day. To me, that is very

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THE WITNESS: No.
MS. ANDREWS: -- appropriate question?
Thank you.
BY MR. GORDON:
Q. So you -- as you sit here today, you have no idea whatsoever what the Bair Hugger's filtration efficiency would be for particles 10 microns in size?
MS. ANDREWS: Objection. Mischaracterizes testimony.
THE WITNESS: I can answer it clearly. It doesn't --
[Reporter requests clarification.]
THE WITNESS: I can answer you clearly. To avoid saying whether the percentage of the filter allows or does not allow, I prevented all from passing. No squames passed through the filter. That's -- that's better than anything.
BY MR. GORDON:
Q. So the Bair Hugger -- you had the Bair Hugger capturing 100 percent of the squames?
A. Not capturing. They ~~We~~ were not allowed to go -- once it reaches the suction on the ~~floors~~ floor, on the bottom of the Bair Hugger, we put their ~~them~~ velocity to zero, the -- the squames will not go anywhere,

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clever in trying to say that what -- anything that isn't rocket science -- it's kind of a colloquial joke, you know, well, it ain't rocket science. I wasn't -- didn't mean you any disrespect, sir.

A. Okay. The same equations used for rocket science are identical equations used for operating room. Both same complexity, yes.

Q. So an operating room CFD would be as complex --

A. Correct.

Q. -- as rocket science?

A. Because the same equations are used. It's called Navier-Stokes equations.

[Reporter requests clarification.]

THE WITNESS: Navier-Stokes.

BY MR. GORDON:

Q. Isn't Navier-Stokes an equation essentially used in almost all fluid modeling?

A. Correct.

Q. So is there any simple system to which Navier-Stokes wouldn't apply?

A. Never. Fluid -- all fluid mechanics use Navier-Stokes equations.

Q. Okay. So is there something -- well, I'll let that pass.

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But this is -- the hydraulic diameter or rectangle. You make a circle of that.
Q. Okay. So you -- do you have a -- do you know what the dimensions are of the duct that your model assumed?
A. It's identical to the hole in the ceiling.
Q. The length of the duct?
A. No, no. The cross-section -- the black is the black.
Q. Okay. And I -- what I'm asking about is from the duct in the ceiling up into the ventilation system, how -- how long -- how high was that, straight --
A. Okay.
Q. -- without any bends?
A. This is -- this length of a duct (indicating), say let's assume it's 10 time the width of the duct, assume.
Q. Okay.
A. This is only a mathematical tool -- excuse me -- to get a velocity profile --
[Reporter requests clarification.]
THE WITNESS: Velocity profile, that is to simulate reality. Because if you don't have this, what people do, they put some approximation to what

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Are you waiting for me or --

BY MR. ASSAAD:

Q. I --

A. Okay. So what people do, using commercial codes, they ask them about some intensity and length scale and they put some numbers and get it. This is the right way to do it, trust me. This is -- will give you a velocity profile almost flat that mimics the grille.

[Reporter requests clarification.]

THE WITNESS: Flat. See the outline here (indicating)? Correct.

THE REPORTER: Grill?

THE WITNESS: Correct.

So if you don't do this, you will get some incorrect profile. This is the right way to do it. that 00at's how we teach people.

BY MR. GORDON:

Q. Okay. Go back to page 31; you were just on it --

A. Okay.

Q. -- if you would.

And at line -- well, there is no line number after 504 on this page, but --

A. Okay.

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clamp on the back?

MS. ANDREWS: Objection. Vague and ambiguous.

THE WITNESS: I don't remember. I did not check.

BY MR. ~~ASSAAD~~ Gordon:

Q. As you sit here today, are you aware of the Bair Hugger ever being used -- either suspended using that clamp on an IV stand or some other elevated plate?

A. I have seen pictures of that, yes, I do.

Q. Your model does not treat the Bair Hugger as being elevated in that way --

A. Correct.

Q. -- is that correct?

A. That is correct.

Q. Your model assumes that the air is discharged along the edges of the drape uniformly, correct?

A. Correct.

Q. And would the correct term for describing the way the air emerges be a slot jet?

A. Uniformly distributed along the edge. The velocity comes from the blower ~~mount~~ outlet. Mass flow rate divided by --

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[Reporter requests clarification.]
THE WITNESS: Mass flow rate divided by the area of the edges of the drape.
BY MR. GORDON:
Q. Right. And but it's -- is that -- does the term "slot jet" have any meaning to you?
A. Yes, of course, yes.
Q. Is what you're describing a slot jet?
A. Okay, but it's -- it's a long -- if you wish, it's a long slot jet. It's along the edges. I mean, the slot jet usually, you know, something like this (indicating). This is distributed
over the length of the drape edges
uniformly of a length, yes.
Q. Okay. Have you ever known anyone who has had surgery with a Bair Hugger?
A. No.
Q. Did you do any research to see what other pieces of equipment might be used in an operating room that generate heat?
A. I know there could be other machines, but I didn't do research on it.
Q. The same question with respect to machines that could generate air currents, did you do any research there?
MS. ANDREWS: Incomplete hypothetical.

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Form.
THE WITNESS: Question again, please.
BY MR. ~~ASSAAD:~~ Gordon
Q. Did you do any research to see if there were other pieces of equipment used in operating rooms that generate air currents?
MS. ANDREWS: Air currents?
MR. GORDON: Yes.
MS. ANDREWS: Same objection.
MR. ASSAAD: You can answer.
MS. ANDREWS: I'm sorry, you can answer.
THE WITNESS: Oh, I can answer? I thought you --
MS. ANDREWS: Forgive me.
THE WITNESS: Okay. The question is -- repeat it. Did I do any research on other devices in an operating room that blow air? Is that correct? No, I did not.
BY MR. ~~ASSAAD:~~ Gordon
Q. Or generate air currents, I guess is what I said.
A. No.
Q. Okay. So your model doesn't consider any other sources of air movement other than the HVAC system and the Bair Hugger; is that correct?

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MS. ANDREWS: Objection.
THE WITNESS: The lamp, the surgical lamp, has higher temperature than the ambient air that creates plume air movement, but because it does not have a blower in it, it's just by buoyancy.
BY MR. ~~ASSAAD~~: Gordon
Q. And thank you. My question is limited to mechanical movement of air, not thermal convection.
[Reporter requests clarification.]
MR. GORDON: Convection.
THE WITNESS: I did not include the computer that has a fan or other device that has fans.
[Reporter requests clarification.]
THE WITNESS: That has a fan. That have a fan, yeah. Yes.
BY MR. GORDON:
Q. Okay. And in terms of heat sources, the only ones that you included in your model were the -- was it two surgeons and --
A. Four...
Q. Four surgeons, two lamps?
A. Two lamps, yes.
Q. And a patient?
A. And the blower.

wrong, but I understand when people do research, they try to -- they don't want to have too many variables so they could determine how one variable acts on the environment. Does that sound correct?

MR. GORDON: Object to the form of the question.

THE WITNESS: It's too general, but if you want to do research, you have to focus ~~in~~ on the main ingredients that matter, yes.

BY MR. ASSAAD:

Q. Okay. And I'm going to jump around a little bit because we are going to try to get out of here.

Earlier today you were talking about the measurements you took at Santa Monica. Do you remember those discussions?

A. Correct.

Q. And your response was: To do, like, temperature and velocity measurements you needed instruments and preparation?

A. Correct.

Q. Okay. What did you mean by that?

A. I meant it will cost you more than a million dollars.

Q. Why?

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A. Because PIV needs four cameras for 3D and two laser sheets and a lot of equipment for storage and trained personnel; all of them must have ~~many~~ PhDs, yeah.

Q. And have you done that in the past?

A. I have not.

Q. But have you done -- have you read research and people doing that in the past?

A. Yeah, I know who -- who are the best in the country.

Q. Okay. And you're familiar with the cost of how much that will cost?

A. Definitely.

Q. Okay. And when you do take measurements, does it make a difference if a person is tak- -- doing it by hand as compared to it being done by computers and PIV?

A. These days, yes.

Q. Why?

A. For accuracy you need 3D measurements --

[Reporter requests clarification.]

BY MR. ASSAAD:

Q. Just repeat your answer. For accuracy?

A. For accuracy, accuracy, yes; for accurate measurements you need qualified people to do the

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measurements, and I'm not talking about flow visualization, like Schlieren ~~sheering~~ and all this. I want people to measure three dimensional velocity components, U, V and W, ~~the~~ function of time and space, and then you can do proper comparison.

Q. People in your field, do they use a hot wire anemometer to take temperature and velocity measurements to validate a CFD study?

A. Not these days.

Q. Why not?

A. Because they're not accurate.

Q. Okay. And the fact that someone is in the room taking that measurements, does that change the results of those measurements?

A. Invasive, you don't not need invasive --

[Reporter requests clarification.]

MR. ASSAAD: Invasive.

THE WITNESS: Invasive.

[Reporter requests clarification.]

THE WITNESS: You -- it should be noninvasive technologies, yes.

BY MR. ASSAAD:

Q. Okay. And when you give a noninvasive, where no one else is in the room, correct?

A. Right.

THE WITNESS: Validated with more complex flows? It's validated with simple to far complex. Starts from a channel flow called isothermal flows.

[Reporter requests clarification.]

MS. ANDREWS: Channel flow. Isothermal flow.

THE WITNESS: Then swirling flows, which ~~is~~ are very complex. No RANS code can do it.

[Reporter requests clarification.]

THE WITNESS: RANS, R-A-N-S. That's an abbreviation.

And then went into particle-laden flows, droplet-laden flows, chemical ~~area acting~~ reactions, swirling droplet flows. These are used for Pratt & Whitney for jet engines. So 15 years of development, every step of the way you validate it with experiments from Pratt & Whitney, from Germany, from Cambridge, all the way. Then after we have a code like this, you know what you're getting.

BY MR. ASSAAD:

Q. And you know that when you -- the -- the model or the fluid flow that the code generates is accurate and valid?

A. Absolutely.

Q. Okay. And who has access to this code?

A. The PhD students who developed it over the years, they have access; post docs and I have access now because I work with them.

Q. And is the code accurate?

A. Yes.

Q. Is it reliable?

A. Yes.

Q. Is it valid?

A. Validated, yes.

Q. And when you say "complex," can you give me real life examples where this code has been validated?

A. So if you have a combustion chamber in a jet engine, like, say, for -- that's used for 737 or 767, it has a spray nozzle that sprays liquid droplets. They evaporate -- evaporate. They mix, they burn. And Pratt & Whitney measures temperature, velocity accurately. And you compare with them, and the paper -- published papers show accurate comparison.

Q. Okay. And let's -- and we've mentioned the word -- the code like ANSYS. Are you familiar with ANSYS?

A. Yeah, I use it for undergraduate teaching.

Q. Okay. You don't use it for your graduate

flow. It's been measured by many people. The most important experiment was done ~~from~~ by Professor Laufer at CalTech.

Laufer L-A-U-F-E-R, in the 1950s. The best, supported by NASA. And Fluent cannot predict the experiment of a simple turbulent pipe flow. Error is quite large errors.

Q. And that's based on your current understanding of Fluent and what you teach in class, correct?

A. Correct.

Q. Okay. So based on what you know about Fluent, would Fluent be reli- -- ANSYS Fluent or ANSYS CFX be reliable in solving particle movement in operating rooms such as you did?

A. Never.

Q. Is it accurate?

A. No.

Q. Would people in your field that do what you do use a software such as ANSYS Fluent or ANSYS CFX to solve particle flow in any situation?

MR. GORDON: Object to the form of the question. Also lack of foundation.

THE WITNESS: The people I'm aware of who are top researchers in the world do not use ANSYS.

BY MR. ~~GORDON~~: Assaad

Q. Because you mentioned -- you said ANSYS is a black box, correct?

A. Because of that, yes.

Q. When you say "black box," what do you mean?

A. You do not know when you select a model from the choice menu -- ANSYS has menus. Menu.

[Reporter requests clarification.]

MS. ANDREWS: ANSYS has a menu.

THE WITNESS: ANSYS. And if you select a menu for a certain model of a certain physical phenomen~~a~~on, you do not know how this is executed.

BY MR. ~~GORDON~~: Assaad

Q. Okay. Would you allow any of your graduate students or PhD students to use ANSYS or Fluent?

A. Never.

Q. All right. With respect to -- okay. I want to talk about the methodology with respect to your conclusions. Okay. My understanding is that you create a geometry, correct?

A. Correct.

Q. How do you create the geometry?

A. We use CAD and we set --

Q. And just, by the way, the methodology that you used in solving this problem, is this the same methodology you've used in other problems?
A. Yes, it's a standard methodology.
Q. And do you know whether or not it's the same methodology used by other people in your field that do what you do?
A. I cannot judge for other people. The good people do that.
Q. Okay.
A. The top people.
Q. The people that you work with at NASA and the Navy and with the NIH, are they the type of people that would use the same methodology as this?
A. Right. I'm talking about people in academia do that work. I don't know about government agencies. But usually the government agenc~~y~~ies ask university to do the important work, and the people who do the important work for government follow that procedure.
Q. I want to jump back, and there was a time when you were asked questions about the boundary conditions.
A. Yes.
Q. Okay. And you kind of -- you kind of

mentioned that it's what you did, like you just thought about it a lot?

A. Correct, yes.

Q. Okay. You didn't just come up with something out of the blue, correct?

A. No.

MR. GORDON: Object to the form of the question.

BY MR. ASSAAD:

Q. Okay. It's not something that you just pulled from thin air, correct?

A. No.

Q. Can you explain what you meant by when you thought a lot about the boundary conditions, what type of mental and mathematical process you went through in your mind?

A. You have to apply certain equations of motion of air over a flat plate and --

Q. What type of equations?

A. Still Navier-Stokes. Navier-Stokes are the equations used everywhere.

Q. Okay.

A. And that will allow you to judge whether the temperature of the edge of the drape is, say, 41 degrees if you have start ed from 42 or something,

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MR. GORDON: It's leading.
MR. ASSAAD: Okay.
BY MR. ASSAAD:
Q. What do you do to establish ~~boundaries~~ boundary conditions?
A. You look at the physics of the problem, and there are rules for boundary condition: What type... Either they're Dirichlet, ~~Dirchilet~~ or Neumann.
[Reporter requests clarification.]
THE WITNESS: Okay. D -- yeah, D-I-R-I-C-H-~~I~~-L-E-T, Dirchilet, and Neumann, N-E-U-M-A-N-N.
BY MR. ASSAAD:
Q. Then are these -- did you perform those calculations in your calculations of boundary conditions?
A. These are rules you follow for setting up the boundary conditions.
Q. Okay. And are those the rules that you follow?
A. Yeah, it's --
Q. Okay.
A. -- a standard thing, yeah.
Q. And you followed it in this -- in this analysis?

Q. Okay.
A. So what --
Q. The next -- sorry, I'm going to go to the sentence that says, "Large number of grid cells result in more accurate solution." Do you agree with that?
A. So in general, larger number of cells ~~in~~ is a refinement, refinement, yes, it should produce that.
Q. Okay. In the calculations that are presented here, up to 60 million grid cells were employed and high accuracy was obtained. Someone in your field that's writing a report regarding a CFD and describing the mesh, would they give an approximation or would they give an exact number?
MR. GORDON: Objection to the form of the question. Also lack of foundation.
THE WITNESS: We give exact numbers.
BY MR. ASSAAD:
Q. Why is that important?
A. That's how we are trained to do it: To report what you used. It's like an experiment; you report to say what you did.
Q. Is the mesh important with respect to the -- to the computer solving the CFD problem?
A. Yeah, definitely; it's a known fact.

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Q. Okay. Now, were these -- were these -- when you put all this stuff in and you had the code, is this done on a regular computer?

A. It depends on the mesh. If you -- if you have a small mesh, you can use a set of computer s connected in parallel, but if you have a very large -- it depends on the equation s you're solving and the mesh -- number of mesh points.

Q. Let's talk about the computers that you used. Did you use your personal computer to solve this?

A. No, no, no.

Q. What computer did you use?

one word

A. You use a super computer.

Q. And where is a super computer located?

A. In different national centers, like Illinois, Texas.

Q. Which one did you use?

A. I used the one in Texas.

Q. Okay. And with respect to your methodology and the super computers, I'd like you to explain how the problem is solved using super computers with the Navier-Stokes equations and relative to the mesh size -- mesh size. Does that make sense or --

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for all this.

BY MR. ASSAAD:

Q. So you agree with me that what -- would you consider Schlierin a reliable test with respect to air flow?

MR. GORDON: Object to the form of the question.

THE WITNESS: Schlierin will give you visualization to what's happening in the flow. It's a good visualization technique. It just -- ~~it~~ you can put a candle. ~~It~~ you can put your hand. You can put hot and cold, and you will see that you can use it for -- yeah, it's a good visualization technique. It will show you what's happening, but cannot tell you how much.

BY MR. ASSAAD:

Q. Can it show particle movement in a -- in a turbulent flow?

A. Okay, Schlierin measures temperature -- density gradients.

[Reporter requests clarification.]

MR. ASSAAD: Gradients.

THE WITNESS: Density gradient.

So it depends on the -- how hot the particles or how cold. I mean, yeah, it's -- I

THE WITNESS: We teach fluid dynamics, so...

BY MR. ASSAAD:

Q. Now, remember, I'm not as smart as you, so try to simplify it as much --

A. Okay.

Q. -- as possible for me.

A. Okay. Okay. When you have a sphere rotating, it's subjected to Magnus effect, M-A-G-N-U-S. And that's a German physicist. And it will create a force, normal to the axis of rotation and the direction of the main flow.

However, in 1968 Professor Saffman, who was in England and later at Caltech ~~architect~~, showed there if ~~is~~ -- a sphere moving in a shear ~~sheer~~ flow is subjected to what's called the Saffman lift. There are many books and papers written about it. And it is essential for formation of sand dunes, for example, in the desert because that sand particle has to jump because it has to be lifted by saltation and you need a Saffman lift force to do that. So the Saffman lift force is an essential part of an equation of motion for nonrotating particles.

Q. Okay. And you took that into account in --

A. Definitely, because if the squames are on the floor, they have to be lifted some way. You need shear ~~sheer~~ to lift them.
Q. And when you measure particles, particle movement, do you use -- there's something called coupling, correct?
A. What do you mean "measure"? I don't --
Q. Or when you -- when you track particles or you -- you --
A. Yes.
Q. -- solve the problem.
A. Yes.
Q. Is there something called coupling? Like single coupling, double coupling?
A. Yes, yes, yes, yes.
Q. So what is that?
A. So, if you have a turbulent flow and you have a particle in it, if you have very few particles, then they would dispersed ~~disbursed~~. Like, if you put some dust, they'll be dispersed ~~disbursed~~ by turbulent flow. However, if you put tons of them, they will affect the turbulence so it become two-way coupling. And if you put more --
[Reporter requests clarification.]
MS. ANDREWS: Two-way.

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THE WITNESS: Two-way.
And if you put much more than that, you get four-way coupling. And they collide with each other in addition to the two-way coupling.
BY MR. ASSAAD:
Q. And is understanding the amount of cells in the coupling very important with respect to a way you solve particle movements?
A. Correct.
Q. Okay. And did someone -- do you know anyone that's written a paper with respect to a map?
A. Yeah, it's myself.
Q. Okay. And has it been named a certain type of map in the community?
A. They refer to it as Elghobashi's ~~mop~~ map.
Q. Elghobashi map, okay.
And when did you come up with this map?
A. In 1991.
Q. Okay.
A. 1990.
Q. And how many times has this article been cited with respect to particle movement in turbulent flow?
A. I don't recall, but 900 or something like that.

the ~~resolve~~ result. We thought, let us see -- put 3 million and see what will happen. We -- any particle collides with it, we will remove it because we don't care about it. We want to see if any of them arrive at that location. Until the very end we did not know.

Q. Okay.

A. So we neglected nonessential stuff. We keep only what matters.

Q. Okay. And -- and -- and is it -- there was some talk about, you know, 3 million being two percent of the squames. Do you --

A. Right.

Q. -- remember that?

A. Right.

Q. Can the -- the analysis that you did, could you run it with 50 million squames?

A. Yes.

Q. Okay. How long would it take to do that?

A. It will take more because very -- the -- the particle computation takes more time than the fluid computation.

Q. What percentage does the particle computation take?

A. Sometimes it takes 70 percent.

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Q. Okay.
A. Because you track each one each microsecond everywhere. That takes a long time.
Q. Is the -- is the model that you -- or the code that you used in this -- in your computational fluid dynamics, in your opinion, the best code that could be used in science today?
A. Based on 15 years of validating by 12 or 15 PhD students, I think it's -- it's used now -- DOE supports it. Everybody supports it. It's an essential thing.
Q. What you say DOE supports it...
A. For jet engines. Fiber content. ?? never said that
Q. So you're telling me the DOE uses the code that you use for jet engines?
A. No, no, no; they ask us to run it.
Q. Okay. So the DOE asked you to run code for jet engines on this co -- on this --
A. Right. It's --
Q. -- on this code?
[Reporter requests clarification.]
BY MR. ASSAAD:
Q. So let me rephrase. Let me rephrase the question.
So the DOE -- people like you consult for

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the DOE and use this code to run solutions for jet engines?
A. For example; for example, yes.
Q. Okay. You also have expertise in DNS, correct?
A. Yeah, correct.
Q. Okay. And you focus a lot of your research in DNS, correct?
A. Correct.
Q. And DNS is direct numerical simulation, correct?
A. Correct.
Q. Could you use DNS on a solution for this operating room?
A. No computer in the world today can handle it.
Q. And why not?
A. Because the Kolmogrov -- okay, the Kolmogrov, K-O-L-M-O-G-R-O-V, Kolmogrov scale is one millimeter in the operating room. And if you divide seven meter, there will be 7,000 millimeter by 7,000, by 3,000 for the height, 49 times three, it's about 140 something. Then 10 to the nine. 149 billion cells. No computer can do it. Not in the world: China, here, yeah.

Q. Let's go to Dr. Abraham's report.
A. This one (indicating).
Q. Let's go to his criticisms of you, and then I'm going to end with your criticisms -- criticism of his report. We'll go little by little.
A. Could you tell me which exactly --
Q. Let's go to page 16.
A. Okay. Yes. I have what I read in the report, only those. Elghobashi's include -- okay, I -- seven. I looked at the seven. I didn't read the reports.
Q. Okay. Well, I'll go to other parts of the report. I just want -- want you --
A. Oh, okay.
Q. -- to comment on --
A. Okay.
Q. Because this is our only chance for you to --
A. Okay.
Q. -- offer any criticisms.
A. Okay, okay.
Q. And I'm sure after you read his deposition, you might have more criticism of his report, but we don't have his deposition yet. It will be after -- in July.

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A. Okay.
Q. His first criticism is: You performed no experiment to validate your model and so your conclusions are unconfirmed and unreliable.
A. I disagree.
Q. Okay. Why do you disagree?
A. Because if you want to do hundred percent validation, you need an experiment using PIV in a room, and nobody published that. So it's a good two -- you need a 2 million dollar to do it.
Q. And you mentioned your code has been validated by --
A. That's the first step. The second step of the -- in the absence of a PIV experiment in operating room, you go back to all the validation of all the flows that has the same physical ingredient s of the operating room, or more.
Q. Okay.
A. Like, the operating room has no additional physics that is not in the validated thing with experiment in the past.
Q. Okay. So -- so if I understand you correctly, you're saying that since the code that you used have done more complex and there's no new physics or new -- new -- I guess no new physics,

that, because it's been validated in the past, it's valid now for your solution?

A. Correct, it's --

Q. What's the Taylor-Green vortex that has been used to validate the LES system that you used, the code that you used?

A. Okay. Taylor-Green vortex is a series of counter-rotating vortices that has an analytical solution, so that's -- when you validate codes, like for undergraduate, the first thing you do, you validate with the very few analytical solution/s from -- Navier-Stokes equation have no analytical solution except for very simple flows, laminar flows. So you tell the student: Go to the analytical solution in a pipe flow and do it and that's fine.

On -- Taylor-Green vortices have an analytical solution, which is more complex than a pipe flow, then you do that, so that's --

[Reporter requests clarification.]

THE WITNESS: Pipe flow, yes. And so on. You go systematically to all the canonical flows: Pipe, ~~Five~~ channel; turbulent. You do all this, based on -- sometimes you use DNS, which is very accurate for these simple flows, and sometimes you do

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experiment. But step by step, you validate for 15 years, and then you know it's good.
BY MR. ASSAAD:
Q. Has DNS ever validated this code that you used?
A. Yes.
Q. How many times, if you're aware?
A. Channel flow, ~~sheer~~ Shear flow.
[Reporter requests clarification.]
THE WITNESS: ~~Sheer~~ Shear flow. Channel flow. I have an accent.
Yes. Yeah, so you do that; that's essential thing. It's mandatory to do that for everything before you use it.
BY MR. ASSAAD:
Q. Before you use the LES code to --
A. Yeah. You have to test it, uh-huh.
Q. And is validating with DNS a type of validation accepted among your peers?
A. Yeah, because DNS is more accurate than experiment.
Q. Okay.
A. Because no human --
Q. So you're -- so you're saying that DNS is more accurate than an experiment?

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A. For a -- for a small number of flows because no computer can handle the room, right?
Q. Okay.
A. So the channel, ~~sheer~~ shear flow, things like that. So you know the code can handle that.
Q. Okay.
A. This is turbulent flow; it's not laminar.
Q. On number two, Dr. Abraham writes, "The expert does not clearly define how the Bair Hugger heated air entered the room. From the incomplete description given, it appears that he has made a serious error by allowing the heated air to emerge along a slot at the edge of the drape. This assumption is in stark contrast to what happens during actual use of the Bair Hugger device and invalidates his analysis."
What is your response of that criticism by --
A. We discussed this today at length. All the air flow that leave the Bair Hugger has to leave the drape somewhere. So we distribute uniformly on that drape edge.
Q. And is that -- is that the calculations when you talked about, you thought about it a lot, that's -- that's the boundary connection?

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A. That's regarding the temperature. But the -- the -- regarding the mass ~~loads~~ flow, it's conserve~~.~~d. Means ~~on a flow~~ -- the air mass flow rate that leave~~,~~s the blower has to come out along the drape because the drape covers everything. That's no assumption.

Q. Okay.

A. The assumption is in the temperature of the edge of the drape.

Q. Okay. Number three, we've already talked about the surgical lamp.

A. Because that was a typo.

Q. Okay.

Oh, by the way, what are your assumptions based upon?

MS. ANDREWS: Do you need this (indicating)?

MR. ASSAAD: I don't need it.

BY MR. ASSAAD:

Q. What are your assumptions based -- you just -- I mean, you base your assumptions on something, correct?

A. About which one? Flow rate or --

Q. About -- about the temperature.

A. The temperature, yeah, I did some estimate

So the faulty premise is how to make a flake move like a sphere, and I already answered that. The second one was about the area, if -- if the area is correct because when you have a flat flake, the drag is called viscous drag. You use the same area. If the flake is normal to the flow ~~floor~~, it's called form ~~of~~ drag. You use the same area.

[Reporter requests clarification.]

THE WITNESS: F-O-R-M, form ~~of~~ drag.

BY MR. ASSAAD:

Q. He writes in red, "The mean that -- this means that the disk is oriented perpendicular to the direction of motion."

A. Yes.

Q. And then he circled, says, "Flow parallel to circular disk." And he says "Inconsistent assumptions."

A. He's wrong.

Q. Why is he wrong?

A. Because the area is the same. He's just -- I made a -- yeah, I made a sketch. If you have a disk flying parallel to the table, the area used is ~~in~~ the surface area for viscous drag ~~direct~~, if the disk becomes perpendicular to the flow, it's called form ~~formal~~ drag. The same area. Just look at undergraduate

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A. Never said that.

Q. Okay. And I'm going to lead, I'm going to get an objection here, but I'm just going to get ~~if~~ it over with, okay.

You're saying to simulate the situation where the air is coming out of the grille, that in a mathematical model you have to create that duct?

A. It's the most correct way to do it; that if anybody says something else, they don't understand fluid dynamics.

Q. Why would it be incorrect to not do it this way?

A. Because if you use~~s~~ ANSYS, apparently the other group used ANSYS, it will tell you what to do ~~I do on~~ at the inlet? They give you choices.

[Reporter requests clarification.]

[Indecipherable cross-talk.]

THE WITNESS: That's okay. And my throat is getting bad.

BY MR. ASSAAD:

Q. I'm almost done, so...

A. They will give you choices.

MS. ZIMMERMAN: We can switch tapes.

MS. ANDREWS: Calm down.

MS. ZIMMERMAN: We'll take a quick break and let the videographer --

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MS. ANDREWS: And you probably need to rest your fingers.

Meet me in my office now.

The Videographer ~~THE WITNESS~~: This concludes DVD No. 3. We're now going off the video record. The time is 6:12.

(Recess.)

THE VIDEOGRAPHER: We are back on the video record. This is DVD No. 4. The time is 6:20.

BY MR. ASSAAD:

Q. I'd like you to turn to page 27 of --

A. Of this --

Q. -- of Abraham's report. F -- number -- of Exhibit 18.

A. 27.

Q. He writes, "Furthermore, his methodology" -- he's talking about you -- "is not accepted by persons in the field of fluid mechanics as they use unvalidated numerical simulation to match real-world results."

A. Which?

Q. 27 of Abraham's report. Not yours. Abraham.

A. I know, but in 27.

Q. Page 27.

A. I know, but at which line?
Q. Under F8. There's no line numbers.
A. Oh, oh, I see.
MS. ANDREWS: "As discussed."
THE WITNESS: Okay. I see. Let me read it.
MS. ANDREWS: Methodology.
THE WITNESS: I never read that. Okay.
"As discussed in this the section, the plaintiff's expert -- is that me, plaintiff expert?
BY MR. ASSAAD:
Q. Yeah. It's been a long day.
A. -- makes several flawed assumptions and basic errors."
I don't know where. I could not -- yeah, I did not do any errors.
Okay. "His methodology in --
Q. He goes, "Further, his methodology is not accepted by persons in the field of fluid mechanics as they use unvalidated numeric simulation to match real-world results."
Do you see that -- do you see where I read that?
A. Yeah, I read it.
Q. Do you agree with that statement?

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A. Of course not. I never read it before. That's -- that's pretty bad.
Q. Let -- let me ask you, are you a member of the National Academy of Engineers?
A. Yes.
Q. What is the National Academy of Engineers?
A. National Academy of Engineering is an independent organization. Has about 2,000 members. It's the highest level of engineering profession in the world, I would say. In the world, yes.
Q. Okay. Do you know whether or not Dr. Abraham's a member of the National Academy of Engineers?
A. I didn't look.
Q. Okay.
A. I don't look at this.
Q. And who was it founded by?
A. President Abraham Lincoln.
Q. Ex- -- go through the story of how the National Academy of Engineers was founded.
A. During the World War -- during the Civil War, in 1865, the president wanted an independent body of scientists and engineers to explain -- give him an opinion on difficult issues that they are not biased and they are not paid by anybody. They --

report, do you know whether or not Dr. Abraham used -- or -- or solved for the particle movement through the operating room environment, or did he do something else?

MR. GORDON: Object to the form of the question.

THE WITNESS: I -- all I see in the report of Dr. Abraham is the fluid particle -- fluid particle -- like motion or, like, tracing of fluid points.

BY MR. ASSAAD:

Q. Okay. What's the difference between tracing of fluid points that Dr. Abraham did and what you did?

A. Okay. If you sprinkle some Powder ~~power~~ in a turbulent flow, these particles do not follow the flow.

Q. Wait. Let -- let me understand. Are you saying particles don't follow air flow?

A. Do not follow the local air flow.

Q. Okay. What do you mean by that?

A. Because particles -- particle motion is controlled by drag, lift, added mass, many other terms, plus buoyancy ~~buoyant~~ -- plus gravity term. If you neglect all these terms, you would be assuming that

THE WITNESS: Reynolds. Yes.
BY MR. ASSAAD:
Q. So as a expert in fluid flow, would you consider any operating room have true laminar flow?
A. Never.
Q. Okay. You have done -- in your CFD analysis, does the -- when the Bair Hugger's turned on, does it increase the intensity of the turbulence around the operating room table?
A. Correct. The intensity increases because the rising plume interacts with the ambient air, creates a ~~sheer~~ shear layer, and therefore, the intensity, ~~turbo~~ turbulence kinetic energy increases.
Q. Okay. This -- the calculation that you've done is -- is basically -- turbulence is very important to the -- to the -- solving this problem?
A. Definitely.
Q. Why is turbulence important?
A. Because turbulence increases dispersion of particles and dis- -- and diffusion of any scaler, like heat or any species. Turbulent is a good mixer.
Q. So turbulent means mixing?
A. Absolutely.
Q. Okay. Now, Dr. Abraham used something

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called the Boussinesq approach.
A. Yes.
Q. Are you familiar with the Boussinesq approach?
A. Yes.
Q. Okay. How does the Boussinesq -- does the Bouss- -- would a -- the Boussinesq approach be the correct approach in a problem such as this?
A. No.
Q. Why not?
A. Boussinesq approach considered the density of the air or the fluid to be uniform, constant everywhere except for the buoyancy term, which appears in the Navier-Stokes equation. And, therefore, the nonlinear terms in Navier-Stokes equation will not have the influence of density variation.
[Reporter requests clarification.]
THE WITNESS: Density variation.
BY MR. ASSAAD:
Q. In -- in a situation like this, how important is density variation?
A. It's crucial, because you have a heating source, whether it's a lamp or the air -- Bair Hugger, or the heads of people, any temperature

of the trach and -- and the -- and the --
A. The whole -- the 3D geometry of the airway.
Q. And you'd use the CFD to how -- how to fix the sleep apnea, correct?
A. Correct.
Q. And what was the -- what was the success rate on the work that you did on the patients that they did?
[Reporter requests clarification.]
BY MR. ASSAAD:
Q. The success rate on the patients that you -- that you did the CFD for and the resolution of sleep apnea?
A. Okay. The -- I don't know many patients to do ~~does~~ this, but in critical operations, they would need something like this because the surgeon doesn't know where the blockage is. So you have to be -- you have to be very accurate in direct simulations to get the right blockage before the operation.
Q. And you would show them where the blockage was with the CFD, correct?
A. Correct, correct, correct.
Q. And they would go operate on -- on the patient, correct?

Q. Okay. Do you know whether or not he used
Lagrange
~~Legrange~~ principles or Euler principles?
A. No, because that would involve particle --
[Reporter requests clarification.]
THE WITNESS: That would involve particles.
BY MR. ASSAAD:
Q. Okay. So it looks like these dotted lines are just air streams, correct?
A. I think --
MR. GORDON: Object to the form of the question.
MS. ANDREWS: Page...
MR. ASSAAD: Page 7 and 6.
THE WITNESS: Right. These look like some -- it's trajectories of something, but it's not -- it's probably points from ANSYS or Fluent.
BY MR. ASSAAD:
Q. Okay.
A. I'm not sure.
Q. Do you know whether or not, based on the report, that Dr. Abraham calculated the turbulent -- turbulent intensity anywhere in the operating room?
A. I cannot say because there are no equations written.

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going do that?

MR. ASSAAD: Objection. Sorry. Communication.

MS. ANDREWS: You can answer.

THE WITNESS: I asked them whether it's okay. I made it only -- not for myself. I made it for the students who did the work. I don't need that paper. I did it only for the poor students who worked for four or five months. That is the only reason. It's not to tell people about it or --

MS. ANDREWS: I think you've answered the question, Doctor.

THE WITNESS: Yeah, yeah. Okay.

BY MR. GORDON:

Q. Earlier you said that the -- that the CFD model that you use is validated every year?

A. Correct.

Q. Why? It's already been validated, right?

A. No. Each year you have different physics. Like in first, will be isothermal flow. Next year, you add particle. Next year, you add ~~vaporation~~ vaporization. Next year, you add chemical reaction. Each step, as I said earlier many times, it has to be validated. You mentioned airplane, when you change something. That's the same thing. Every time you put new

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physics, you have to validate it again. So now it's a ~~validate~~ validation for so many pieces of the puzzle.

Q. I'm -- what do you mean by new physics of an airplane?

A. Okay. You were sitting here and you said if you have an airplane flying and then you make a change, you have to do something to the -- to the education of the pilots or something. You said that here today. When I said it's like a plane, I mentioned a plane has been tested for four years, then they allow passengers to use. And you said --

[Reporter requests clarification.]

THE WITNESS: Then you can allow passengers to use it. And you said but if a plane has been flying and then you make a modification, you have to test it. I don't remember what you said, but it should be in the record here. So I'm saying now the code has been running for isothermal flows, you test it. Another student comes, you do it for particles; you test it again because you have new physics.

So the jet engine test has all the physics ~~he~~ you can think of, compressible, particles, vaporization, heat transfer --

[Reporter requests clarification.]

1 Calculation of velocity and temperature of heated air leaving the BH blanket

The objective of this report is to calculate the velocity and temperature of heated air as it leaves the BH blanket and enters the OR. In order to calculate the air temperature we need to calculate the heat transfer rate from the air to the patient's chest and arms. Since the heat transfer between the air and body occurs by forced convection, then we need to compute the velocity of the air as it moves between the BH blanket surface and the body.

1.1 Velocity of heated air leaving the BH blanket

Figure 1 shows the planar geometry of the BH blanket Model 522 before inflating it.

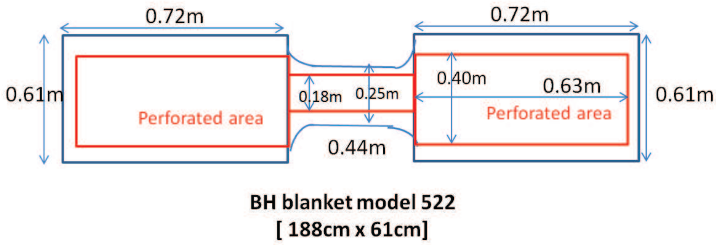

Figure 1: BH blanket geometry before inflation

In order to calculate the velocity of the air leaving the blanket we should consider the shape of the inflated blanket when it is connected to the BH blower as shown in Fig.2.

Figure 2: BH Inflated Blanket. The dimensions with the red arrows are for PDF scaling only.

Fig.3 shows a cross-section of the inflated blanket after being wrapped around the arm.
The diameter of the cylindrical surface facing the arm $=0.194m$ which when unwrapped flat would produce the width of the blanket ($=0.61m$) as shown in Fig.1, according to $L=\pi D$.
The width of the heated-air gap between the arm and the blanket surface $=\frac{(0.194-0.127)}{2}=0.0335m$.
The heated air issuing from the blanket holes (one thousand holes, each 1mm diameter) leaves the blanket across that gap on the right and left arms.
The total cross-sectional area of both the right and left gaps

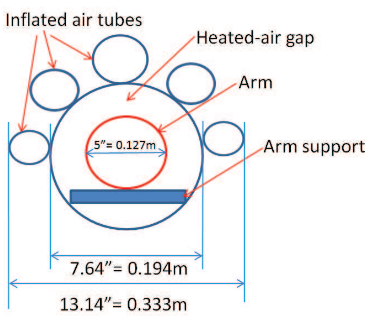

Figure 3: BH cross-section of inflated blanket

$= 0.0335 \times 0.61 \times 2 = 0.04087 m^2$.

Thus, **the velocity of air leaving the right and left arms**=

$$\frac{\text{Blower volumetric flow rate}}{\text{gap area}} = \frac{0.021\,\mathrm{m}^3/\mathrm{s}}{0.04087\,\mathrm{m}^2} = \mathbf{0.514}\,\mathrm{m/s}$$

It should be noted that this is the velocity *before the air reaches the drape* that covers the blanket. The air will then leave the drape edges at a lower velocity as shown in Fig.4.

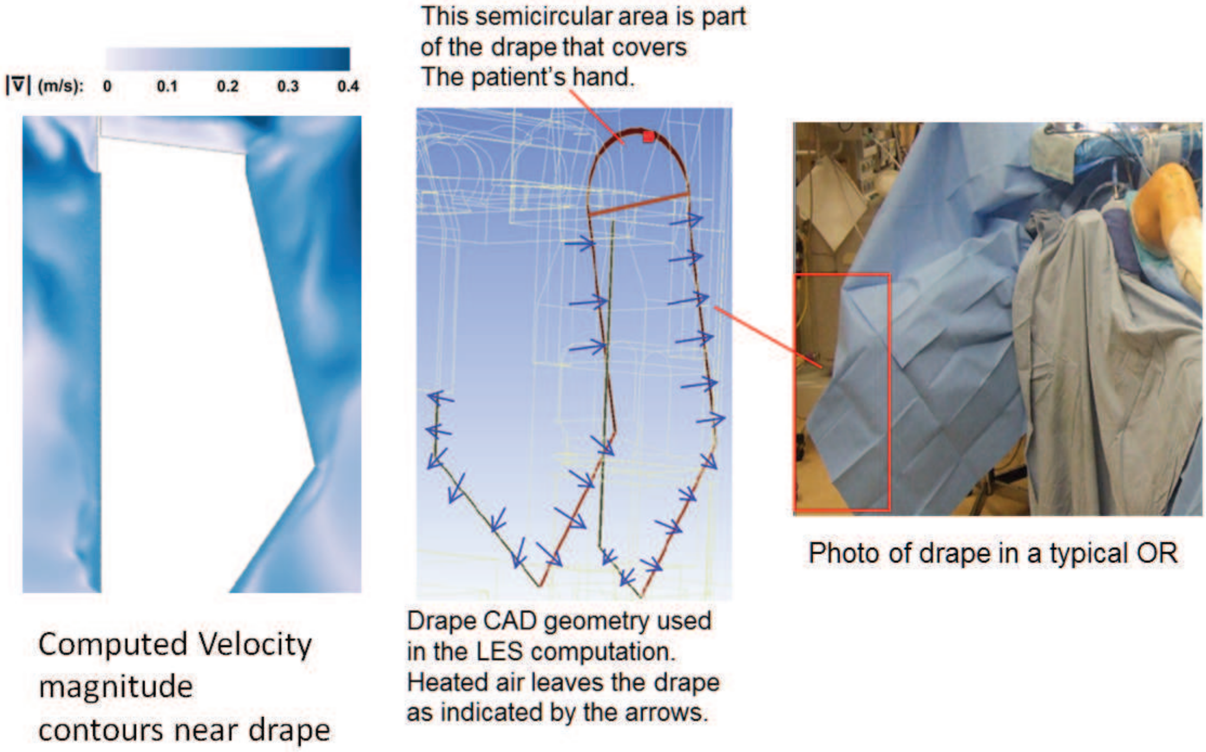

Figure 4: Drape geometry and heated air velocity near the drape.

1.2 Temperature of heated air leaving the BH blanket

In order to calculate the exit air temperature we apply the First Law of Thermodynamics to the control volume shown in Fig.5. For a steady-state condition we have:

$$\dot{m}_{in}\; h_{in} = \dot{m}_{exit}\; h_{exit} + \dot{q}_{body}\;, \tag{1}$$

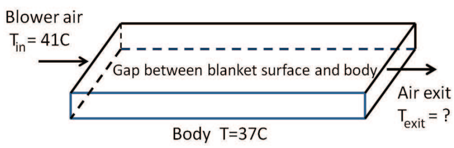

Figure 5: Schematic for heat transfer from air to body

where

$\dot{m}_{in}$= mass flow rate of blower air (kg/s)

= air density $\times$ volumetric flow rate = 1.1236 $\times$ 0.021 = 0.0236 kg/s ,

$\dot{m}_{exit}$= $\dot{m}_{in}$= $\dot{m}$ = mass flow rate of air leaving the blanket = 0.0236 kg/s,

h_{in}= enthalpy of air from the blower (kJ/kg),

h_{exit}= enthalpy of air leaving the blanket (kJ/kg),

$\dot{q}_{body}$ = rate of convective heat transfer from the air to the body (kJ/s= KW).

Since $\dot{m}$ is constant, Eq.(1) can be recast as:

$$h_{in} = h_{exit} + \dot{q}_{body}/\dot{m}, \tag{2}$$

The inlet enthalpy, h_{in}, is obtained from Thermodynamics Tables of air (e.g. [2], page 660) at the temperature of 41C. The Table gives $h_{in} = 314\,\mathrm{kJ/kg}$. Our goal is to find h_{exit} since it

will give us T_{exit} via Thermodynamics Tables of air. Thus, we must first calculate the heat transfer to the body, $\dot{q}_{body}$.
Since the heat transfer from the air to the body is by forced convection, we have

$$\dot{q}_{body} = h_c \times \text{Area of blanket surface} \times (\mathrm{T_{air}} - \mathrm{T_{body}}) \ , \tag{3}$$

where h_c is the coefficient of convective heat transfer from air to body. This coefficient

Figure 6: Heated air temperature near the drape.

depends on the air velocity that was calculated in the previous subsection as 0.514m/s. Reference [1] provides the values of h_c for different parts of the body as a function of the air velocity. For a velocity of 0.514m/s, $h_c = 5W/m^2K$. The temperature difference is $T_{air} - T_{body} = (41 + 273.15) - (37 + 273.15) = 4K$. The area of the blanket surface delivering the heated air is marked by the red contours in Fig.1:
Area=$2(0.63 \times 0.4) + (0.44 \times 0.18) = 0.5832\mathrm{m}^2$. Substitution in Eq.(3) gives:

$$\dot{q}_{body} = 5\mathrm{W/m^2K} \times 0.5832\mathrm{m}^2 \times 4\mathrm{K} = 11.664\mathrm{W} \tag{4}$$

Substitution in Eq.(2) gives:

$$314\,\mathrm{kJ/kg} = \mathrm{h_{exit}} + 11.664\mathrm{W}/(0.0236\mathrm{kg/s}), \tag{5}$$

which results in $h_{exit} = 314\,\mathrm{kJ/kg} - 0.494\,\mathrm{kJ/kg} = 313.506\,\mathrm{kJ/kg}$.
Using this value of h_{exit}, and the Tables in [2], page 660, gives $\mathbf{T_{exit} = 40.5C}$.

It should be noted that as the body temperature rises above 37C due to the continuous (e.g. for one hour) heating by air, the value of $\dot{q}_{body}$ will be reduced, and the exit air temperature T_{exit} will approach 41C asymptotically, as shown in Fig.6.

References

[1] R.J. de Dear, E. Arens, Z. Hui, and M. Oguro. Convective and radiative heat transfer coefficients for individual human body segments. *Int J Biometeorol*, 40:141–156, 1997.

[2] R.E. Sonntag, C. Borgnakke, and G.J. Van Wylen. *Fundamentals of Thermodynamics, 6th Ed.* Wiley, New York, 2002.

I, Witness , do hereby declare under penalty of perjury that I have read the foregoing transcript; that I have made any corrections as appear noted, in ink, initialed by me, or attached hereto; that my testimony as contained herein, as corrected, is true and correct.

Executed this 13th day of July, 2017, at IRVINE, CA.

(City) (State)

A. Eghbashi

Witness

Volume

UNITED STATES DISTRICT COURT

DISTRICT OF MINNESOTA

IN RE: BAIR HUGGER FORCED AIR WARMING PRODUCTS LIABILITY LITIGATION THIS DOCUMENT RELATES TO: ***All Actions***	**MDL 2666** **Judge: Hon. Joan N. Ericksen**

PROOF OF SERVICE

I am over the age of 18, employed in the County of Orange, State of California, and not a party to the within action; my business address is 2 Corporate Park, Suite 110, Irvine, CA 92606.

On July 14, 2017, I served a copy, with all exhibits and attachments, of the foregoing documents:

- **ERRATA TO DEPOSITION OF SAID ELGHOBASHI**
- **PROOF OF SERVICE;**

on the party or parties named below, by sending a true copy thereof via electronic mail, and sent as follows:

Jerry W. Blackwell
Mary Young
Benjamin Hulse
BLACKWELL BURKE P.A.
431 South Seventh Street, Suite 2500
Minneapolis, MN 55415
Phone: (612) 343-3256
Fax: (612) 343-3205
Email: blackwell@blackwellburke.com
Email: myoung@blackwellburke.com
Email: bhulse@blackwellburke.com

__XX__ **BY E-MAIL/ELECTRONIC TRANSMISSION:** Based on a court order or an agreement of the parties to accept service by e-mail or electronic transmission, I caused the documents to be sent to the persons at the e-mail address listed in on the service list. I

did not receive, within a reasonable time after the transmission, any electronic message or other indication that the transmission was unsuccessful.

XX **FEDERAL**: I declare that I am employed in the office of a member of a bar of this court whose direction the service was made.

I declare under penalty of perjury under the laws of the United States of America that the foregoing is true and correct.

Executed on July 14, 2017, at Irvine, California.

/s/ John C. Thornton
John C. Thornton (CASBN 84492)

Deposition of Expert Said Elghobashi, Ph.D.
Mechanical and Aerospace Engineering

Page Line	**Correction**	**Reason**
113, 2-116, 7	Further Clarification of Exhibit B to Errata filed on 7/13/17	Clarification of the thinking and analysis I performed that permitted me to calculate a reliable and accurate boundary conditions of the temperature and velocity at the drape. This analysis involved methodology that I could not explain verbally during the deposition. The explanation required mathematical formulae and illustrations which are contained in Exhibit B.

I, Witness Said Elghobashi, do hereby declare under penalty of perjury that I have read the foregoing transcript; that I have made any corrections as appear noted, in ink, initialed by me, or attached hereto; that my testimony as contained herein, as corrected, is true and correct.

Executed this 19th day of July, 2017, at Irvine, California.

(City) (State)

S. Elghobashi

Witness

Volume

UNITED STATES DISTRICT COURT

DISTRICT OF MINNESOTA

IN RE: BAIR HUGGER FORCED AIR WARMING PRODUCTS LIABILITY LITIGATION

THIS DOCUMENT RELATES TO:

All Actions

MDL 2666

Judge: Hon. Joan N. Ericksen

PROOF OF SERVICE

I am over the age of 18, employed in the County of Orange, State of California, and not a party to the within action; my business address is 2 Corporate Park, Suite 110, Irvine, CA 92606.

On July 19, 2017, I served a copy, with all exhibits and attachments, of the foregoing documents:

- **SUPPLEMENTAL ERRATA TO DEPOSITION OF SAID ELGHOBASHI**
- **PROOF OF SERVICE;**

on the party or parties named below, by sending a true copy thereof via electronic mail, and sent as follows:

Jerry W. Blackwell
Mary Young
Benjamin Hulse
BLACKWELL BURKE P.A.
431 South Seventh Street, Suite 2500
Minneapolis, MN 55415
Phone: (612) 343-3256
Fax: (612) 343-3205
Email: blackwell@blackwellburke.com
Email: myoung@blackwellburke.com
Email: bhulse@blackwellburke.com

__XX__ **BY E-MAIL/ELECTRONIC TRANSMISSION:** Based on a court order or an agreement of the parties to accept service by e-mail or electronic transmission, I caused the documents to be sent to the persons at the e-mail address listed in on the service list. I

did not receive, within a reasonable time after the transmission, any electronic message or other indication that the transmission was unsuccessful.

XX **FEDERAL**: I declare that I am employed in the office of a member of a bar of this court whose direction the service was made.

I declare under penalty of perjury under the laws of the United States of America that the foregoing is true and correct.

Executed on July 19, 2017, at Irvine, California.

/s/ John C. Thornton
John C. Thornton (CASBN 84492)